

Biomechanical scaling of the curvature of the mandibular condyle and glenoid fossa in primates. C.J. VINYARD, CM Biology, Northwestern University, Chicago, IL. 60611.

Theoretical consideration of weight-bearing joints in the postcrania suggests that joint curvature will decrease with increasing body mass holding other factors constant. Given that joint reaction forces should be normal to a joint articular plane to avoid damaging shear forces, this joint flattening is explained as a size-required effort to resist greater joint stresses created by increasing body mass.

Although not weight-bearing, the temporomandibular joint (TMJ) performs a load-bearing role in the primate cranium. To date, the hypothesis that there are size-required changes in TMJ curvature has not been tested. Previous research suggests that masticatory stresses may increase disproportionately with size due to the tendency for larger primates to have physically tougher diets relative to smaller primates. Thus, it is predicted that the mandibular condyle will become flatter and the glenoid fossa will become more concave with increasing cranial size in primates.

Estimates of curvature for the condyle and glenoid fossa were calculated in anteroposterior (AP) and mediolateral (ML) planes from measurements of the condyle and glenoid fossa using a 3D Reflex microscope. Species means were analyzed for 52 strepsirrhine and 47 haplorhine taxa. The predicted relationships between curvatures and size were assessed via Product-moment correlations ($\alpha=0.05$) between curvatures and jaw length as a skull size estimate.

AP condylar curvature is not correlated with jaw length. Conversely, AP glenoid curvature is significantly correlated with mandibular length (-0.453). Contrary to the prediction, the glenoid becomes increasingly convex with larger size and joint congruity decreases. Both ML condylar (-0.452) and ML glenoid (-0.335) curvatures are correlated with jaw length (tarsiers and indrids were excluded due to their clearly derived ML curvatures). These results demonstrate that as size increases the condyle increases ML curvature, while the glenoid becomes slightly more concave.

The predicted size-required changes in TMJ curvature are not met. As the TMJ does not routinely disarticulate in larger primates, these results led to several alternative explanations: 1) stresses in the TMJ are not relatively greater in larger taxa, 2) the articular disc helps to maintain joint congruity, 3) other factors, such as gape, have more important effects on joint form and/or 4) clade-specific influences on curvature invalidate a primate-wide analysis.

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The influence of locomotor function on postcranial variation in hominoids and monkeys. P.S. VINYARD, Department of Anthropology, Washington University, St. Louis, MO 63130.

Research on primate postcrania has focused mainly on discerning functional morphological differences among broad categories of locomotor behavior. Few studies have examined variation in postcranial elements among closely related extant primates. Even less work has been done on the relationship between variation and locomotor function. As certain anatomical and skeletal regions in a species are fundamental to locomotion, stabilizing selection may act as a functional constraint suppressing the amount of variation in those complexes.

The hypothesis that limb dominance in locomotor function influences levels of variation will be tested using *Homo*, *Pan troglodytes*, *P. paniscus*, *Gorilla*, *Pongo*, *Hylobates lar*, *Cebus apella*, *Macaca fascicularis* and *Papio papio*. A priori assignments were made as to limb dominance in these primates. For this study *Homo*, *Pan* and *Gorilla* are considered hindlimb dominant; *Hylobates*, forelimb dominant; and *Pongo*, *Cebus*, *Macaca* and *Papio* do not exhibit limb dominance. It is predicted that increased variation will be found in dimensions from the non-dominant limb. For example, *Hylobates* should display more variation in the hindlimb than the forelimb. No difference in variation is predicted in those taxa not expressing limb dominance.

97 measurements were taken on the humerus, radius, ulna, femur and tibia. Variation was quantified by the CV and the multivariate CV. Variables were analyzed by species hierarchically beginning with inclusion of all variables. Subsequently, variables were grouped by serially homologous regions as well as biomechanical criteria focusing on load-bearing, force-producing and kinematic functions. Univariate CVs were assessed using Mann-Whitney U-tests ($\alpha=0.05$) and multivariate CVs by F-ratios ($\alpha=0.05$). Univariate results uphold the predicted relation between function and limb dominance; however, only *Homo* shows the predicted differences in variation using the multivariate CV. These results demonstrate that there is some support for the link between limb function and variation, but functional constraints do not have an overriding affect across all limb measures. It is clear that variational differences between fore- and hindlimbs need to be more specifically related to functional parameters.

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Native American Birth Seasonality at the California Missions. P.L. WALKER, Department of Anthropology, University of California Santa Barbara, CA, 93117 and J.R. JOHNSON Santa Barbara Museum of Natural History Santa Barbara, CA, 93105

The seasonal birth pattern of 7932 American Indians living at seven southern California missions between 1774 and 1888 was analyzed using baptismal records, marriage records, and other historical sources. These data show that there were differences in birth pattern among the missions (Santa Ynez, La Purisima, Santa Barbara, San Buenaventura, San Luis Rey, San Luis Obispo, San Fernando) and also a secular trend related to the shift from hunting and gathering to agriculture. Overall, the monthly distribution of births shows a strong seasonal pattern with a major peak in the spring, a minor peak in the early winter, and a trough in the fall.

When the birth pattern is analyzed according to the historical phases of the missionization process, a secular trend can clearly be seen. During the first ten years after the establishment of a mission, births were strongly seasonal with a major peak in the late winter and a minor peak in the fall. Later in the mission period, the magnitude of seasonal variations in birth

rate decrease significantly. After the collapse of the mission system, strong birth seasonality reemerges in which the peak birth period has shifted from the winter to the late spring and early fall. This pattern is similar to that seen in Spanish-Mexican colonists living in California during the post-mission period.

These changes in birth seasonality are the result of a complicated set of interactions among environmental, physiological, and cultural variables. California's strongly developed winter rainfall pattern clearly influenced the seasonal pattern of births during the transition from hunting and gathering to an agriculture-based economy. Several historical processes interacted with environmental and economic factors to transform the seasonality of births in this population.

A survey of remodeling in the vertebrate skeleton, part II. R.A. WALKER, Dept. of Anatomy, New York Chiropractic College, Seneca Falls, NY 13148-0800. C.O. LOVEJOY, Dept. of Anthropology, Kent State University, Kent, OH 44242

Modeling and remodeling are responsible for both the emergence of the skeleton and its continuous repair during adulthood. Local mechanical loading clearly plays a key role, but considerable debate continues over the nature of the transduction signal(s). Much research has been designed to illuminate them, but a relatively untapped source of information is their phyletic history. The current research continues previous work on intraindividual bony variation in the domestic cat (*Felis domesticus*). Significant left/right differences were found in the histomorphology of the forelimb but not the hindlimb. The current work presents a similar analysis of the skeleton of the domestic chicken (*Gallus gallus*). We hypothesized that such asymmetries should not exist in its forelimb, because of presumed symmetry of loading. The analysis included the left and right femora, tibiae, humeri, radii and ulnae. Each bone was transversely thin sectioned intervals of 10 % along its length. Cross sectional properties were calculated for each section, including: area moment of inertia about the AP and ML axes (Iap, Iml), polar moment of inertia (J); and cortical and total cross-sectional areas. Numbers of secondary and fragmentary secondary osteons, and percent haversian bone were determined for each section. Comparisons were made between proximal and distal limb segments, serially homologous fore and hindlimb bones, and contralateral bone pairs. Proximo-distal variation was also examined. The asymmetry of the cat forelimb, particularly in the ulna, suggests that remodeling is affected by side dominance. This was not found to be the case in the chicken. To further examine the side dominance hypothesis, 14 pairs of human ulnae were also examined for side variation in histomorphology. They were significantly asymmetric. These data support the hypothesis that local remodeling is influenced by only moderate asymmetry of limb use. This research is supported in part by a grant from the Research Department at New York Chiropractic College.

ABSTRACT WITHDRAWN

EMG of the Anterior Temporalis Muscle in Adult Male Baboons. C. E. WALL, K. R. JOHNSON, and W. L. HYLANDER, Dept. of Biol. Anthropology & Anatomy, Duke University Medical Center, Durham NC 27710.

In anthropoids, the superficial part of the anterior temporalis muscle has more fast-twitch fibers than the deep part. Fast-twitch fibers generate higher forces and do so more quickly than slow-twitch fibers.

We studied the EMG activity patterns of the deep and superficial parts of the anterior temporalis in three adult male baboons (*Papio anubis*) to test the hypothesis that the proportion of fast-twitch fibers is correlated with the production of large bite forces during mastication. This hypothesis predicts that in comparison to activity in the deep part, activity in the superficial part should be of shorter duration, i.e., it should be confined mainly to the power stroke of mastication with little (if any) activity during fast closing. It also predicts that increased activity levels in the superficial part during hard-food versus soft-food mastication should be greater than in the deep part.

Our results indicate a high level of functional differentiation in the anterior temporalis and confirm both predictions of the hypothesis. Duration of activity in the superficial part is relatively short compared to the deep part. Overall, both the rise time and the fall time of the rms EMG are faster and onset in activity is later than in the deep part. Furthermore, the superficial part is relatively more active than the deep part during the chewing of hard food as compared to the chewing of soft food. In fact, the superficial part is frequently inactive when the subjects chew soft foods.

These data suggest that the role of the superficial anterior temporalis is to produce high levels of force quickly (e.g., during the power stroke of hard food mastication). This is consistent with the presence of a large proportion of fast-twitch fibers in the superficial as compared to the deep part of the anterior temporalis.

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Still no evidence for a tail in *Proconsul heseloni*.

C. V. WARD, University of Missouri, Columbia, MO, A. WALKER, Pennsylvania State University, University Park, PA, M. F. TEAFORD, The Johns Hopkins University, Baltimore, MD.

Harrison (1998: AJPA Suppl. 26: 93) recently presented fossils from the Kaswanga Primate Site on Rusinga Island, Kenya, as evidence that *Proconsul heseloni* had a "relatively long external tail." This contrasts with our earlier conclusion that *Proconsul* lacked a tail.

Two vertebral specimens, V9 and V10, are central to this argument. Harrison suggested that they are caudal vertebrae, but re-examination of these fossils confirms our original unpublished interpretation: these specimens are crushed and distorted lumbar, not caudal, vertebrae.

Both specimens are sheared roughly in half longitudinally, making them appear narrower than they would have been in life. The pedicles and transverse processes are broken off near their bases, but their relative position and contours resemble the condition found on all anthropoid lumbar vertebrae but never on caudal ones. In addition, the morphology of the endplates, orientation of intervertebral surfaces, and body contours are consistent only with lumbar vertebral anatomy.

The ultimate sacral vertebra, V42, originally described by Ward et al. (1991: J. Hum. Evol. 21:215), is indeed poorly preserved. Whether an ultimate sacral or first caudal, its morphology clearly demonstrates that it did not support a significant number of caudal vertebrae. Instead, it is strikingly similar to that of a young chimpanzee of roughly the same body size as *P. heseloni*. An admittedly weaker, though supporting, line of evidence is in the complete absence of caudal vertebrae from KPS. This site preserves 10 partial skeletons of *Proconsul* with 40-50 vertebral fragments, but none is a caudal element.

The phylogenetic significance of these results has been discussed extensively. As *Proconsul* is considered a stem hominoid by most researchers, and a stem catarrhine by others, the retention of a tail would not necessarily affect interpretations of its phylogenetic position. If it lacked a tail, however, it would share this derived trait with all extant hominoids, indicating that it was a member of the hominoid clade and not a stem catarrhine.

We are confident in stating that at the present time there is still no evidence to suggest that *Proconsul* had a tail.

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Regional Differences in Cranial Morphology

MW WARREN, HA WALSH-HANEY, KR SMITH, PR STUBBLEFIELD, JJ SCHULTZ, and AB FALSETTI.
Department of Anthropology, University of Florida,
Gainesville, FL 32611

A traditional source of skeletal reference material for anthropological research has been anatomical collections of known age, sex and race. These collections may not serve as appropriate reference populations because of their temporal remoteness and inherent sampling biases. Concern about documented secular and/or microevolutionary change between historic and modern populations has prompted the organized collection of contemporary skeletal data (i.e. University of Tennessee's forensic data bank, or FDB). This paper contributes to the growing body of data representing contemporary populations and examines to what extent our regional sample varies from other contemporary and historic collections.

Our study is based on a modern forensic sample consisting of positively identified remains analyzed at the University of Florida (UF) since 1980. Only individuals positively identified by fingerprints, dental comparison, and/or skeletal antemortem/postmortem radiographic comparisons are included. Eight cranial variables, common to both Giles and Elliot and Fordisc analyses, are used to compare the UF sample with the FDB.

Following Ayers, et al (1990), the UF data ($n_1=68$) were first subjected to the Giles and Elliot discriminant function analysis to assess the accuracy of the method when applied to a modern forensic sample. Separating our study sample into four categories, (white male, black male, white female, black female), the univariate means of each category were compared via t-test to the comparable means of the Giles and Elliot sample ($n_2=75$). The same procedure was used to compare mean discriminant function scores for each category.

Preliminary results show that the UF sample more closely corresponds to the FDB sample than Giles and Elliot's Terry and Hamann-Todd sample. Both the FDB and UF samples differ from Giles and Elliot's sample for many of the same variables. Observations of specific trends are discussed and possible reasons for these differences explored.

Variation in catarrhine ectotympanic development and morphology. J. WARSHAW, Hunter College and The Graduate Center, CUNY/NYCEP, New York, NY 10036.

A semi-cylindrical external auditory meatus is recognized as one of the characters of extant Catarrhini. While this feature does appear in all living members of the infraorder, the adult

and developmental morphologies, as well as the rate at which the ectotympanic ossifies laterally during ontogeny, may vary. Many authors have described the development and morphology of the external auditory meatus within catarrhines, as well as all other mammals. However, a comprehensive account of catarrhine variability does not exist.

In this study, 102 juvenile catarrhine crania from the American Museum of Natural History Mammalogy collection were dentally aged—based on maxillary eruptions—and divided into four growth categories. Specimens range in age from newborn through the eruption of complete deciduous dentition. Genera from all extant catarrhine subfamilies, except Ponginae, were included in the study. A system was devised to score the ontogenetic stage of each specimen, based on observation of developmental morphology of the ectotympanic. Scores were recorded for each genus at each dental age category. Small sample sizes within genera for each age category prohibited the use of quantitative methods for comparison between taxa.

Results show that all catarrhines share a similar ectotympanic ontogenetic sequence. However, specific taxonomic patterns within select genera and subfamilies were identified. *Papio* displays a posteriorly directed tube, a distinct crest along the ventral surface of the ectotympanic and an accelerated development relative to all other taxa except *Erythrocebus*. *Colobus*, and possibly other colobines, appear to be developmentally retarded relative to other cercopithecoids. *Hylobates* develops a uniquely smooth ectotympanic cylinder, angled anteriorly. Hominine ectotympanics, especially those of *Gorilla*, are robust and more intraspecifically variable in their morphology than those of cercopithecoids and hylobatids; they proved difficult to score using this system.

Ontogenetic differences are of interest in light of the proposal that the ectotympanic cylinder is an auditory buffer for chewing sounds generated in the glenoid articulation (Packer & Sarmiento, 1984). Lack of consistent correlation between developmental stage and dental age suggests that factors such as adult cranial morphology and mechanics, life history, and behavior must also be considered in order to account for the variability within and across taxa.

Laterality of hand function in the naturalistically-housed chimpanzees of Chester Zoo, U.K. J. A. WEGHORST¹,² and A. W. FLETCHER², ¹Department of Anthropology, Washington University, St. Louis MO 63130-4899. ²Department of Zoology, Miami University, Oxford OH 45056.

Studies of laterality of hand function in chimpanzees (*Pan troglodytes*) have the potential to tell us about the origins of handedness in *Homo sapiens*. However, the data are confusing, with discrepancies present between studies done in the field and laboratory: the former show wild chimpanzees to be unlateralized at the population level, while the latter show captive chimpanzees as lateralized at the population level. This study of 26 semi-free ranging chimpanzees of Chester Zoo, England, aims to provide ethological data for 43 categories of habitual movement, mostly of the upper limbs. Other variables recorded were indoors/outdoors and arboreal/terrestrial, as well as age and sex of the apes. Using switching focal subject sampling, 28,269 bouts of behavioral patterns were recorded. Pooling all bouts of manual non-tool use results in an overall significant right handedness (51% R: 49% L). However, when the data

are analyzed at the level of individuals and behavioral patterns, a clearer picture emerges. Over all behavioral patterns (non-tool use), 6 individuals have left hand specializations, 9 have right hand specializations, and 11 are ambidextrous; thus there is no predominance of left or right-preferenced individuals. Similarly, no single behavioral pattern has a significant bias of left or right-preferenced individuals. No sex or age differences emerge. The hand preferred for an activity is independent of whether the other hand is idle or providing bodily support and of whether the individual is terrestrial or arboreal. Seven of the 17 tool-using chimpanzees exhibit left-hand specializations, while none have right-hand specializations, with the data suggesting a trend toward left-handed tool use lateralization.

Thus, group-living, semi-natural chimpanzees show more similarity in manual laterality to wild chimpanzees than to caged chimpanzees in laboratories. Discrepancies between field and laboratory studies could be due to the degree of human influence, lack of an ethological approach, or other methodological differences.

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Altitude and climatic influences on *Macaca* morphology. K.J. Weinstein, Department of Anthropology, University of Florida, Gainesville, FL 32611-7305.

Macaca represents an ecologically variable and geographically dispersed genus that inhabits a wide range of localities from lowland tropical rainforests to cold climates and elevations up to 4000 meters. Although locomotor factors contribute to interspecific variations in body size and proportions, closely related *Macaca* species should also exhibit morphological characters that follow the predictions of Bergmann's and Allen's rules. Those species that inhabit cold climates and high altitudes ought to have larger, wider body masses and shorter appendages compared with their lowland, tropical conspecifics.

This study compares skeletons of *Macaca mulatta* (n=60) and *M. assamensis* (n=20) recovered from elevations above 2000 meters with their lowland conspecifics and four other *Macaca* species that differ from the two highland samples according to the following ecological variables: *M. fascicularis* (n=60) in terms of climate, altitude, body size, and locomotion; *M. radiata* (n=20) in terms of altitude, climate, and body size; and *M. fuscata* (n=20) and *M. nemestrina* (n=60) in terms of climate and altitude. All samples are comprised of museum collections of adult, wild-shot specimens with known provenience.

In order to distinguish the effects of altitude and climate on *Macaca* morphology, I compare sex-specific means of humeral, radial, tibial, and femoral lengths, trunk height as determined by the summed length of thoracic and lumbar vertebral bodies and sacrum, and trunk width as determined by bi-iliac breadth. Using least squares bivariate and multiple regression analyses, these measures of body proportions are compared with altitude and lowest mean monthly temperature, and estimates of body mass as determined by articular surface area of the proximal and distal humerus and femur. The samples recovered from colder climates and higher elevations tend to exhibit shorter limb proportions for their size, which suggests that cold temperatures characteristic of highland and northern environments may be important factors influencing intra- and interspecific variation in *Macaca* body size and proportions.

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Sexual Differences in Activity Patterns of a Central Californian Hunter-Gatherer Population. E. Weiss, ENDY, University of Arkansas at Fayetteville, AR 72701.

This project examined the skeletal remains of a 3,000 year old hunter-gatherer population from the San Joaquin Valley, to determine whether a sexual division of labor existed. Cortical bone remodels itself throughout an individual's lifetime in response to the stresses experienced by activity patterns. Cortical bone densities and orientation, therefore, reveal the nature of the stresses caused by different activity patterns. Computer tomography was used to obtain femoral cross-sections for sixty-four individuals (30 females, 34 males), taken at two levels along the diaphysis of the bone: at the subtrochanteric and midshaft levels. Two types of ratios were calculated for each cross-section: (1) the maximum cortical thickness compared to the thinnest cortical layer (I_{max}/I_{min}) to determine the maximum bending stress, and (2) the anteroposterior orientation compared to the mediolateral orientation (I_x/I_y) to determine the direction from which the major bending stresses are coming. Student's t-tests and Analysis of Variance were used to analyze the difference in means and variances of the ratios for the sexes. Comparisons were made to the findings of other femoral cross-sectional dimensions in similar preagricultural and agricultural populations. The statistical tests revealed that two of the four ratios (I_x/I_y at the subtrochanteric and midshaft levels) showed a significant difference at the 90% confidence level between males and females. At both levels, male femoral cross-sections showed a greater anteroposterior orientation than did female femoral cross-sections. These results suggest that males were using their gluteus maximus and medius, biceps femoris, vastus lateralis and medialis more than were females. The gluteus maximus extends the femur during running and walking vigorously. The gluteus medius abducts the femur and stabilizes the pelvis during gait. The biceps femoris extends the femur and flexes the knee. The vastus lateralis and the vastus medialis flex the femur and extend the knee. All five of these muscles are important for bipedal traveling and cause an anteroposterior orientation of the femoral shaft when used extensively. It is, therefore, suggested that males were doing more long distance travel than were females. Females were probably participating in food preparation close to a home base, as suggested by the archaeological evidence.

Asymmetry in Arikara long bones. D.J. WESCOTT, University of Tennessee, Knoxville, TN 37996 and D.L. CUNNINGHAM, University of Missouri, Columbia, MO 65211

An examination of bilateral asymmetry in limb bones can assist when scrutinizing patterns associated with habitual physical activities. Activities requiring equal use of the right and left limbs result in a relatively small degree of bilateral asymmetry. On the other hand, activities requiring a greater use of one limb over the other will induce

an increased bone density and mass in the dominant limb bone. The outcome of this increased bone mass is more pronounced bilateral asymmetry of the limb bones.

Asymmetry was examined in humeri and femora from four Arikara sites (39WW1, 39SL4, 39WW2, and 39CO9). Length, head diameter, epicondylar breadth, least circumference of diaphysis, and total cortical area at midshaft and 35% from the distal end were examined in the humeri. Measurements of the femur include length, head diameter, bicondylar breadth, and subtrochanteric and midshaft total cortical areas. The data were tested for sex and temporal differences.

Results indicate that males have a significantly greater degree of asymmetry in humeral total cortical area than do females. This suggests that Arikara males were habitually involved in activities requiring the use of one arm more frequently than females. There is also an increase, although not significant, among males in the total mean cortical area through time.

Modelling species lineages. K. P. WESSEN and C. E. OXNARD, University of Western Australia, WA, 6907, Australia.

An earlier model of species evolution indicated that the actual patterns of evolution based on all species were very different from those based only upon simulated fossils (Oxnard, Conf. Centre Asian Studies, U. Hong Kong, 4: 476-497). The present study expands upon that model using computer implementations that allow thousands of simulations and provide statistical descriptions. Migration, extinction and fossilisation rates can all be varied in different ways, and various constraints may be applied to simulate species distributions of particular "shapes".

Simulations proceed from single ancestral species with particular suites of "characters". A small number of characters may vary as each species evolves. Using only extant and fossil species, a phylogeny is constructed, and its features compared with the known true phylogeny.

In several sets of a thousand runs each, the numbers of extant species in the model were restricted to from 4 to 6 (thus modelling the numbers of extant hominoids). The numbers of prior species per generation were held considerably greater so that the species distribution through time was amphora-shaped).

The results show that, even with a high fossilisation rate of 10%, the number of fossils leading to living species is rather small, most fossils being on extinct lines. The most recent common ancestor of the living species is close to the stem of the model, 20 - 25 species generations back, and is usually not a fossil. This contrasts with reconstructions extant and fossil species alone, where most fossils seem to

lead to living species, and where the most recent common ancestor are usually very recent fossils.

These models, more complex than most actual phylogenetic studies, therefore imply that we should be more cautious in relating fossils to one another, that we should expect far more fossils to lie on extinct lines than generally suggested, and that recent times for common ancestors of living species are unlikely. They have particular implications for phylogenetic studies of hominoids.

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Periostitis - more than just "non-specific infection": a comparison of medical museum and archaeological bone specimens. D.A. WESTON, Institute of Archaeology, University College London, London, UK WC1H 0PY

The recording of periosteal reactions or "periostitis" in archaeological skeletons is an important aspect of the palaeopathological investigation of human skeletal remains. Periosteal reactions are an ideal candidate for study as they are a relatively common occurrence in human skeletons, particularly on the tibiae. Where periosteal reactions become problematic is in their pathogenesis. A diagnosis of "non-specific" infection, within the parameters of the skeletal stress response, has been often concluded, despite the fact that periosteal reactions can occur due to a number of pathological conditions. Trauma, neoplasms, metabolic disorders, circulatory disease, as well as infection, can all result in their production.

There is an inconsistent system of recording periosteal reactions in the palaeopathologic literature. Though suggestions have been made to standardise the recording of these common lesions (e.g. Rose *et al.*'s Skeletal Database Committee Recommendations and Buikstra and Ubelaker's Standards for Data Collection...), in fact, much of the literature reveals an almost individualised approach to the recording of these data.

Bone samples demonstrating periosteal reactions and illustrating various disease processes were studied from documented pathological specimens archived in London-based pathology museums. The samples were subjected to macroscopic, radiographic, and SEM-backscattered electron imaging analysis in order to determine if the characteristics of the periosteal reactions were specific to the corresponding disease states. These investigative techniques were then also applied to an archaeological human skeletal population. This results of these analyses will be presented.

Sexual dimorphism of the human lumbar spine
K.K. WHITCOME, Department of Anthropology, Southern Illinois University, Carbondale, IL 62901

Orthograde positional behaviors place unique demands on the lower flexible spine. While human lumbar vertebrae

accommodate complex forces generated during bipedal locomotion, transfer of these forces along the descending lumbar column differs significantly between males and females. The human lordotic curve, affected by dorsal wedging of lumbar vertebrae and their intervertebral disks, is the result of cumulative contributions. Slight differences in size and shape of the articular surfaces and supporting structures at each level combine to effect noticeable change in the lumbar column. This study will examine lumbar vertebrae in *Homo sapiens*, *Pan troglodytes*, and *Gorilla gorilla gorilla*.

Twenty-six measurements were taken on the centrum and right and left zygapophyses at each lumbar level for both sexes of the three taxa. Variables were adjusted for body size then analyzed for sex differences with Model II nested ANOVA, Wilcoxon rank-sum, and PCA.

Sexual dimorphism occurs in all five lumbar levels of *H. sapiens*. Ventral wedging of the centrum characterizes both sexes at L1. However, L1 wedging is greater in males and persists to L2. The transition to dorsal wedging occurs more cranially in females, extending from L2 to L5. Dorsal wedging in males begins at L3 and proceeds to L5. Females exhibit a less pronounced lordotic curve extending across a greater length of the lumbar column. Additionally females are characterized by greater prezygapophyseal obliquity, depth, and surface area at L2, L3, and L4.

Of the four lumbar vertebral levels of *P. troglodytes*, sexual dimorphism occurs only in the prezygapophyseal depth and surface area of L4. No differences were detected for *G. gorilla gorilla*.

Specialized spinal morphology in the lumbar region of humans is not fully explained by structural adaptation to bipedalism. Adaptations to obstetric selection extend beyond the pelvis to the adult lumbar column, resulting in significant sexual dimorphism of lumbar vertebrae in *H. sapiens*.

Infant feeding practices at Altun Ha, Belize: four stable isotope measures. C.D. WHITE, Department of Anthropology, University of Western Ontario, and F.J. LONGSTAFFE, Department of Earth Sciences, University of Western Ontario.

This study compares the potential of stable carbon isotope data ($\delta^{13}\text{C}_{\text{col}}$, $\delta^{13}\text{C}_{\text{ap}}$, $\Delta^{13}\text{C}_{\text{col-ap}}$) to identify breastfeeding and reconstruct the weaning process with the established $\delta^{15}\text{N}$ method. Two subsamples controlled for status and time period are compared with the entire sample of 57 Maya from Altun Ha, Belize, which spans the Preclassic (ca. 800 B.C) to Postclassic (post A.D. 1200) periods. One of the controlled subsamples is a sacrificial group which may not be comprised of local individuals.

Weaning effects in the entire sample are dampened by dietary variability due to status and time period differences, but are more clearly exhibited in the two controlled subsamples. In this case, $\delta^{15}\text{N}$ and $\Delta^{13}\text{C}_{\text{col-ap}}$ appear to be the most reliable

indicators of infant feeding practices. A trophic level difference in $\delta^{15}\text{N}$ and differences in collagen-apatite spacings are found in all three groups. The $\delta^{15}\text{N}$ trophic level effect is consistently around 2 ‰, but the magnitude of $\Delta^{13}\text{C}_{\text{col-ap}}$ varies from 1.1 to 4.3 ‰. This variation is attributed to differences in the macronutrient composition of the weaning diet, and is consistent with the hypothesis that the sacrificial group is not local. However, similar $\Delta^{13}\text{C}_{\text{col-ap}}$ in the youngest (i.e. breastfeeding) groups agrees well with the consistent $\delta^{15}\text{N}$ trophic level effect, and suggests that the duration of exclusive breastfeeding was a shared Maya behaviour. The introduction of solid foods is estimated to have occurred between ages 2 and 6, which complements enamel hypoplasia data for this and other Maya sites.

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Cheek pouch use in *Papio cynocephalus*. J.C. WHITHAM, University of Illinois, Urbana, IL, 61801; J.E. LAMBERT, Southwest Missouri State University, Springfield, MO 65804.

Cercopithecine monkeys are readily distinguished from colobines and ceboids by the presence of cheek pouches. It has been suggested (e.g., Murray, 1975; Lambert, 1998) that a major selective pressure in the evolution of this anatomical feature comes from maximizing energy extraction in a context of feeding competition over limiting resources. Wild cercopithecines have the capacity (at least potentially) to reduce feeding competition by increasing inter-individual feeding distances, or by switching food resources. However, this flexibility is not available to animals in captivity, where foraging spheres are defined by enclosure parameters and feeding options are limited to zoo diets.

In this project, we evaluate patterns of cheek pouch use in captive adult baboons (*Papio cynocephalus*). Observations took place at the Brookfield Zoo, Brookfield, Illinois, between June and September 1998. Instantaneous scan samples of the troop were taken at five minute intervals throughout the day. Time of day, sex, activity category, and cheek pouch use were recorded. When possible, degree of cheek pouch fullness was determined; following Hayes et al. (1998) the scale included: empty, 25%, 50%, 75%, and 100%.

Over 117 hours of direct observation resulted in a total of 3058 cheek pouch records. The baboons were observed to cheek pouch food in 59% of these records. Adult females used their cheek pouches significantly more often than males ($X^2 = 168.7$; $P < 0.00$), and, on average, the females had fuller cheek pouches (mean fullness: females 66.4% vs. males 39.7%). Although rank was not determined for all animals, overall, higher ranking animals were less likely to use their cheek pouches than lower ranking animals. In general, the captive baboons cheek-pouched food at a higher percentage than those reported (Lambert, 1998) in wild cercopithecines, suggesting that cheek pouches may be more commonly employed when animals are unable to increase inter-individual feeding distances.

Information stemming from this captive research will be interpreted in light of information collected previously

on wild cercopithecines. The ecomorphological relationship(s) between oral anatomy, feeding ecology, and intra-specific food resource competition will be evaluated and discussed.

Pleistocene dispersal of African hamadryas baboons onto the Arabian peninsula. DEREK E. WILDMAN, Department of Anthropology, New York University & NYCEP, New York, NY 10003. U.S.A.

The hamadryas baboon (*Papio hamadryas hamadryas*) is found both in Africa and on the Arabian peninsula. The subspecies is the only baboon whose range extends beyond continental Africa. Today the baboons' range is disjunct with the Red Sea acting as an extrinsic barrier to gene flow between continental and peninsular hamadryas populations. Mitochondrial DNA sequences and nuclear short tandem repeat genotypes have been used to estimate the dates of dispersal of African hamadryas populations onto the Arabian peninsula. Results include sequences and genotypes from Yemeni, Saudi Arabian, and Ethiopian hamadryas baboon populations, as well as data from appropriate papionin outgroup taxa. Genetic data were analyzed using phylogenetic and population genetic techniques, and these analyses suggest that a dispersal onto the peninsula occurred during the middle Pleistocene. The results when combined with geological, climatological, biogeographic and historical evidence enable the following points of discussion. Hamadryas baboons were not introduced onto the Arabian peninsula by Egyptian or other historic human populations. The baboons may have dispersed across a now submerged isthmus at what today are the straits of the Bab al Mandeb at the southern end of the Red Sea, rather than across the Sinai peninsula. Humans were not the only terrestrial mammal to migrate out of Africa during the middle Pleistocene. This research was supported by Sigma Xi, the American Institute for Yemeni Studies, and the National Science Foundation.

How do Neandertal and modern human infants become Neandertal and modern human adults? F.L. WILLIAMS, Department of Anthropology, University of Massachusetts, Amherst, MA 01003.

Modern humans and Neandertals are quite different as adults in craniofacial size and shape. However, little attention has been paid to how these differences arise. Are differences between adults of the two taxa manifested at birth or do they develop during post-natal ontogeny? How far do modern human and Neandertal adults depart from their infant morphologies? And finally, how do patterns of allometric growth help to explain differences in adult craniofacial shape? To address these questions, craniofacial variables from neuro-orbital, facial-masticatory and mandibular regions were obtained from a sample of 39 juvenile and adult original Neandertal fossils and an ontogenetic series of 272 modern humans ranging from fetal weeks to 50 years. For this analysis, size is defined

as a sum of all variables comprising a craniofacial region, and shape is constructed as a suite of ratios of given variables to their regional summary size. Each shape ratio is between 0 & 1.

Euclidean distances between infant and adult centroids reveal that much of the difference observed between adults of the two taxa arise during post-natal ontogeny for the neuro-orbital region but in the mandible, differences are present soon after birth. Modern humans tend to preserve early post-natal morphologies much more than do Neandertals; i.e., modern adults resemble modern infants in much of their craniofacial shape. Growth allometries help to explain how these differences come to be. Patterns of allometric growth tend to differ in Neandertals and modern humans. Neandertal infants become Neandertal adults via strong positive and negative allometric growth patterns whereas modern humans tend to be closer to isometry for all regions and in particular for the neuro-orbital region.

Research supported by US Fulbright, Belgian American Educational Foundation, NACEE, Faculty of Medical Sciences, Groningen University and Sigma Xi.

Morphological correlates of gummivory in the skull of prosimian primates. S. H. WILLIAMS and C. E. WALL, Dept. of Biol. Anthropology & Anatomy, Duke University Medical Center, Durham NC 27710.

This study tests whether skull morphology in gummivorous prosimians reflects foraging behavior (gouging and intense scraping of gums) when compared to prosimians that do not feed substantially on exudates. To this end, we use models developed by Spencer and Demes (1993), which show various ways to reposition the anterior dentition and the masticatory musculature to allow for more efficient and powerful incisal biting, and models by Hylander (1979a, b; 1984) relating to mandibular buttressing patterns for withstanding anteroposterior and vertical shear at the symphysis, sagittal bending of the corpus, and loads at the condyle.

The models were evaluated by measuring thirteen cranial and mandibular features in gougers (*P. fuscifer*, N=2 and *E. elegantulus*, N=10) and scrapers (*G. crassicaudatus*, N=22 and *G. s. moholi*, N=22). *G. demidovii* (N=22) and *G. alleni* (N=12) were measured as the comparative group. Shape ratios were created by dividing each variable by the geometric mean of all variables. Nonparametric statistics were used to test for significant differences.

The results show associations between gummivory and skull morphology. The scrapers and gougers have significantly ($p<0.01$) smaller mandibular and tooth row lengths than the non-scrapers but are not distinguished from one another. This means that the anterior dentition is positioned relatively close to the TMJ in gougers and scrapers. Moment arm lengths of the masticatory muscles are relatively short or equal in the scrapers and gougers

compared to the non-scrapers. However, this decrease is proportionately less than the decrease in mandibular length so that the efficiency of the muscles is actually slightly greater in the scrapers and gougers.

Finally, the scrapers and gougers show significant ($p<0.01$) increases in relative symphyseal length, symphyseal width, corpus depth at M_1 , and mediolateral condylar width compared to non-scrapers. Gougers were distinguished from scrapers in having a relatively long symphysis. Future work on the mechanics of gouging and scraping should provide a better understanding of the functional significance of this difference.

Research supported by a Ford Foundation Predoctoral Fellowship and a Duke Endowment Fellowship to SHW.

Genetic epidemiological approaches to understanding the determinants of susceptibility to Chagas' disease in rural Brazil. S. WILLIAMS-BLANGERO, J.L. VANDEBERG, J. BLANGERO, and A.R.L. TEIXEIRA, Southwest Foundation for Biomedical Research, San Antonio, TX 78245 and University of Brasilia, Brasilia, Brazil.

Chagas' disease is an extreme consequence of infection with the parasitic protozoa *Trypanosoma cruzi*. The disease continues to be a major public health concern throughout Latin America despite numerous control and eradication programs. Between 16 and 18 million people are infected with *T. cruzi* and that a further 100 million individuals are at risk of infection.

T. cruzi is transmitted to humans by several genera of triatomine bugs including *Triatoma*, *Rhodnius*, and *Panstrongylus*. Transmission occurs subsequent to the blood meal when feces deposited by infected bugs come into contact with open wounds or mucous membranes. There are currently no prophylactic drugs available to prevent infection with *T. cruzi*.

A study of the determinants of susceptibility to infection with *T. cruzi* was initiated in Posse, Goiás in 1995. This comprehensive study proposes to quantitate the effects of genetic and environmental factors influencing susceptibility to this infection of major public health concern. We have already established that there is a significant heritability to susceptibility to *T. cruzi* infection. A genome scan is being undertaken to localize the specific genes involved.

Three candidate chromosomes were screened using variance component based linkage analysis of 188 individuals belonging to a single complex pedigree. We tested for linkage between the genotypic markers and both the dichotomous infection trait and several possible correlates of Chagas' pathogenesis, including nitric oxide levels and soluble cell adhesion molecules. While preliminary, our results continue to support a large genetic component for *T. cruzi* infection and quantitative correlates.

Modeling gross occlusal wear in *Gorilla gorilla* using dental topographic analyses. M.D. WILLIAMSON and P.S. UNGAR, Anthropology and Center for Advanced Spatial Technologies, University of Arkansas, Fayetteville, AR 72701.

Numerous workers have demonstrated relationships between molar tooth form and function in extant primates. Such relationships have been used to infer diet from teeth of fossil forms. These studies have focused on unworn teeth. Still, because most fossil teeth are worn, it is necessary to understand how gross wear affects occlusal morphology, and how this affects the abilities of teeth to break down foods with given material properties. The study described here uses geographic information systems technology to examine the effects of gross wear on dental morphology in lowland gorillas.

In this study we examine lower second molars of *Gorilla gorilla gorilla* specimens representing five stages of wear, defined by degree of dentine exposure. Three-dimensional points were collected on the surface of each tooth using an electromagnetic digitizer, and resulting data were imported into GRASS 4.1 following Zuccotti *et al.* (1998). Tooth surfaces were then interpolated using a thin-plate spline model. Various aspects of occlusal topography including elevation, slope, profile curvature (*i.e.*, rate of change of slope), and surface area were computed for each specimen. This approach allows us to model changes in tooth morphology through an idealized wear sequence.

Results show location, degree, and spatial extent of topographic changes in occlusal morphology as a tooth wears. These changes can likely be associated with concomitant changes in the ability of gorilla molars to initiate and propagate cracks in foods with given material properties. Techniques described here can also be used to document how morphological attributes change with respect to one another, to examine other characteristics of occlusal topography such as facet slope and aspect, and to compare the effects of wear on tooth shape among taxa.

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Selection for a toxic staple crop: meeting nutritional requirements in a blackwater basin of Northwest Amazonia. W.M. WILSON, and D.L. DUFOUR, Dept. of Anthropology, University of Colorado, Boulder, CO 80309

Obtaining sufficient dietary energy can be difficult in blackwater basins of Amazonia. The Tukanoan Indians, of the Colombian Vaupes, have met this challenge in an apparently counterintuitive manner: they rely on a varieties of manioc (*Manihot esculenta* Crantz) which are dangerously cyanogenic for 70-80% of their dietary energy. Despite the fact that the Tukanoans do grow some low-cyanide manioc, approximately 99% of the manioc that they cultivate and consume has high-cyanide concentrations. This research was carried out to further our understanding of the Tukanoan preference for a toxic

staple crop. It tests the hypothesis that high-cyanide manioc is preferred because it produces higher yields than low-cyanide manioc.

This hypothesis was evaluated in several ways. First, 160 high-cyanide and 160 low-cyanide manioc plants were harvested in 10 traditional Tukanoan gardens. Second, a control garden was planted with 48 high-cyanide and 48 low-cyanide manioc plants and harvested ten months later. In the traditional gardens, the yield of high-cyanide manioc was significantly greater than that of the low-cyanide manioc (matched-pairs t-test, $p = 0.037$). In the control garden, the percentage of high-cyanide manioc plants that survived in the control garden (54%) was significantly greater than that of the low-cyanide plants that survived (17%) (small-sample binomial, $p = 0.002$). These results supported the yield hypothesis.

A scenario is proposed explaining that yield is one of the factors that explains the preference for high-cyanide manioc. This research improves our understanding of human adaptation to tropical rainforests and has important implications for international manioc breeding programs.

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Assessing intragroup genetic variation of free ranging mantled howling monkeys on the island of Ometepe, Nicaragua. L. WINKLER, X. ZHANG and R. FERRELL. School of Public Health, University of Pittsburgh, Pittsburgh, PA 15261.

Previous studies of genetic diversity within troops of howling monkeys (Pope, 1992) report relatively high levels of mean heterozygosity. Pope (1992) suggests that high levels of heterozygosity offer a selective advantage for adaptation, particularly to diverse or new habitats. The present study examines intragroup variation of DNA in the mantled howling monkey (*Alouatta palliata*) in a tropical dry forest environment on Isla de Ometepe, Nicaragua. This population of howling monkeys is unique in its isolation on Ometepe for thousands of years but is increasingly threatened by increases in human population on the island and subsequent fragmentation of its habitat by human disturbance (Garber *et al.*, in prep). Blood samples were taken from all of the adult males (5), 5 of the 8 adult females and from one subadult of a howling monkey troop as part of a capture, mark, and release project (Winkler *et al.*, in prep). DNA was extracted from blood (which had been isolated and frozen prior to analysis). PCR techniques were utilized to examine 11 microsatellite loci which had been previously identified for *Alouatta palliata* (Ellsworth and Hoelzer, 1997). We successfully amplified 8 of these loci in our samples.

Our results indicate considerable homozygosity for these loci within this troop. Two of the loci had previously been identified as monomorphic within howling monkey species (Ellsworth and Hoelzer, 1997) and our results are consistent with that. However, the remaining 6 loci had been reported to be polymorphic (3-6 alleles) in samples from wild populations of *A. palliata*. All of our samples were homozygous for four of these loci. A single adult female (although a different female for each loci) was heterozygous and the remainder of the troop homozygous for the other two loci. Such a high level of

homozygosity raises a number of questions regarding group formation, composition, and inbreeding. These issues as well as the implications of this homozygosity for species survival and distribution on the island where its habitat is increasingly fragmented by human activity are discussed.

The assistance of Ometepe Biological Field Station and Drs. Greg Peter and Rex Sohn is gratefully acknowledged. This research was supported by University of Pittsburgh research funds.

An Australasian test of the Recent African Origin Theory using the WLH-50 Calvarium. MILFORD H. WOLPOFF, JOHN HAWKS, STEPHEN OH, KEITH HUNLEY, SETH DOBSON, GRACIELA CABANA & PRAVEEN DAYALU. Paleo-anthropology Laboratory, Department of Anthropology, University of Michigan, Ann Arbor MI 48109-1382.

This analysis investigates the ancestry of a single modern human specimen, WLH-50. Evaluating its ancestry plays a central role to our understanding of modern human origins in Australasia because the prevailing models make different predictions for it. Some authors propose that modern humans in Australasia descended solely from ancestral modern human populations found in Late Pleistocene Africa and the Levant. These ancestral modern populations completely replaced other archaic human populations, like the Ngandong hominids. According to this theory the archaic humans from the region are classified as *Homo erectus*, a different evolutionary species that could not have contributed to the ancestry of modern Australasians. The complete replacement theory makes clear predictions, which we tested using two distinct methods: a discriminant analysis of metric data for the three samples that are potential ancestors of WLH-50 (Ngandong, Late Pleistocene Africans, Levant hominids from Skhul and Qafzeh) and a pairwise difference analysis of non-metric data for individuals. These procedures yielded unambiguous results. A model of complete replacement was unquestionably refuted and the results indicate that the Ngandong hominids may have contributed significantly to the ancestry of WLH-50. Therefore, our contention is that the Ngandong hominids or a population like them should be classified within the evolutionary species, *Homo sapiens*. The Multiregional model of human evolution has the expectation that Australasian ancestry is in all three of these groups, Ngandong, Skhul and Qafzeh, and Late Pleistocene Africans, and best explains modern Australasian origins.

Patterns of craniofacial variability in living primates and *P. boisei*. B.A. WOOD and D.E. LIEBERMAN. Dept. Anthropology, The George Washington University, Washington DC 20052.

The discovery of the large male robust australopithecine skull at Konso Gardula (KGA 10-525) raises several important questions about intraspecific variation in living primates and fossil hominids. In order to test whether KGA 10-525 fits within the predicted range of variation in the *Paranthropus boisei* hypodigm, it is necessary to determine which characters (e.g., polymorphisms) are reliable indicators of intra- versus inter-taxonomic variation. Of special importance is the extent to which one can identify characters that are expected to show higher than average

levels of variability because of non-genetic responses to mechanical loading.

Sexed crania of *Homo sapiens*, *Pan troglodytes*, *Gorilla gorilla*, *Pongo pygmaeus*, *Papio* sp., and *Colobus guereza* were used to evaluate the taxonomic utility of cranial characters present in KGA 10-525 and other craniodental remains attributed to *P. boisei*. Characters were evaluated on the basis of experimental and biomechanical evidence for their functional role in resisting masticatory forces.

These analyses indicate that, among primates, intraspecific morphological variation is significantly greater in highly "epigenetic" regions of the cranium that counteract high masticatory stresses than in less developmentally plastic regions. In addition, characters which belong to generalized functional matrices, such as the braincase, typically exhibit similar, covarying patterns of variation. As a result, characters whose size and shape are strongly affected by masticatory adaptations (e.g., *m. temporalis* size) are more likely to yield misleading estimates of taxonomic diversity than characters whose growth is less affected by non-genetic stimuli.

The results support the hypothesis that KGA 10-525 falls within the previously-predicted range of variation for *P. boisei*. They also highlight the importance of considering the developmental and functional basis for polymorphisms on a character-by-character basis as part of the process of assembling and testing systematic hypotheses.

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Distributional patterns and origins of European Y chromosome haplotypes. E.T. WOOD-PAVICICH, M.R. BONNER, T. KARAFET, University of Arizona, Tucson, AZ; A.S. SANTACHIARA-BENERECETTI, Università degli Studi di Pavia, Pavia, Italy; B. BONNE-TAMIR, Sackler School of Medicine, Ramat Aviv, Israel, and M.F. HAMMER, University of Arizona, Tucson, AZ.

Genetic markers on the non-recombining portion of the Y chromosome are employed to trace the origins of paternal lineages in Europe. Previous work indicated a European clinal gradient of YAP*4 haplotypes from the southeast (e.g., ~30% in Greeks) to the northwest (e.g., <5% in Britain). To further address Y chromosome variation in Europe, we surveyed 14 biallelic markers in 2320 males from 42 worldwide populations including 7 European, 3 Middle Eastern, and 3 North African populations. These markers gave rise to 15 Y chromosome haplotypes, 7 of which were found in our European sample. When combined with variation at two Y-linked microsatellites we identified 31 combination haplotypes in 350 European, Middle Eastern, and North African males.

The most ancestral YAP*4 chromosomes (YAP*4L), estimated to have originated approximately 20,000 BP, were limited to Ethiopian populations. Our data are consistent with the hypothesis that derived YAP*4S haplotypes migrated from Ethiopia to Egypt where they increased in frequency before expanding into Europe. The distributional pattern of this haplotype fits the Neolithic Demic Diffusion model in which agriculturalists spread from the Middle East starting ~10,000 BP. However, this haplotype only accounts for a minor portion of European Y chromosomes. A major fraction of our European samples consisted of haplotype 1R chromosomes. The age of this haplotype (>50,000 BP) and its widespread North African distribution suggest that it originated in Africa and moved into Europe during the Paleolithic. Haplotype 1C chromosomes, making up a large portion of our northern European sample, showed a clinal pattern that is opposite to that of YAP*4 chromosomes. Three of the four remaining European haplotypes exhibited very different distributional patterns, apparently varying on

east-west axes. Although the African-derived 1R and YAP* 4 haplotypes comprise between 70% and 16% in our European samples, a large portion of the Y chromosome haplotypes examined in this survey (1C, 1D, 1U and 1I) appear to originate in Asian populations. These results may indicate a rather large Paleolithic *and* Asian contribution to the European paternal gene pool.

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Factors contributing to interspecific differences in play frequency of Kibale Forest monkeys. E.A. WORCH, Education Department, University of Michigan-Flint 48502

Play is considered vital for the development of skills which help prepare young primates for adult roles (Fagen, 1993; Fairbanks, 1993; Markus & Croft, 1995); however, the amount of time wild primates devote to play ranges from zero (*Saimiri*: Baldwin & Baldwin, 1974) to about 12 % of the time observed (vervet infants: Govindarajulu et al., 1993). Temporary food shortages (Baldwin & Baldwin, 1972; Boccia et al., 1988) and group size (Baldwin, 1969; Cheney, 1978) have been linked to intraspecific differences in play frequency, but little is known about factors that contribute to interspecific variation.

In this study, the play behavior of the red colobus and black-and-white colobus monkey and the redbellied and blue guenon was observed over a 12 month period. Diet, day range and group size were examined to test the following hypotheses: (1) the energy hypothesis - play frequency is positively correlated with dietary quality; (2) the budget hypothesis - play frequency is negatively correlated with day range; and (3) the group size hypothesis - play frequency is positively correlated with social group size.

The colobines had folivorous diets and small day ranges, whereas the guenons had frugivorous diets and large day ranges. Within each subfamily, the two species differed by group size. The colobus monkeys were significantly more playful (12.9 %) than the guenons (1.4 %). This led to a rejection of the energy hypothesis and to a failure to reject the day range hypothesis. Within each subfamily, group size had little impact upon the amount of time a species played.

The guenons had to work harder to find food. With regard to play frequency, the advantages of a high-quality diet were offset by the demands of finding, harvesting and processing food. The colobines had to travel much shorter distances to meet their caloric demands. The ability of the colobines to spend more time at the same location facilitated conditions conducive for play. The time and individual-proximity demands imposed by each subfamily's foraging strategy seemed to have a greater influence upon the amount of time a species played than the size of the social group.

Comparative ecology of human sleep. C.M. WORTHMAN, Emory University, Atlanta, GA.

A significant domain of human behavior that claims a third of daily life but remains largely overlooked by anthropologists is sleep. While the discipline has examined virtually every other aspect of human activity, sleep has not been studied. Meanwhile, sleep research has proceeded to characterize the ontogeny and physiology of human sleep and sleep architecture, as well as to extensively document comparative animal sleep/rest behavior and biology across animal taxa. But the comparative study of sleep has not extended to population variation in humans. Although sleep deprivation and chronobiological experiments have monitored acute and mid-range effects of manipulated sleep ecologies, the developmental and lifetime ecologies of sleep normative among western populations studied so far, appear to the anthropologist as scarcely representative of the extant and expectable range of human sleep ecologies. Specifically, western patterns of solitary sleep on heavily cushioned substrates, consolidated in a single daily time block, and housed in climate-controlled and completely enclosed space, contrast with the variety of sleep conditions among traditional societies. These conditions include multiple and multi-age sleeping partners, frequent presence of animals, embeddedness of sleep in ongoing social interaction, fluid bed- and waketimes, use of nighttime for ritual, sociality, and information exchange, and relatively exposed sleeping sites that require fire maintenance and sustained vigilance.

This paper presents an analytic framework for comparative human sleep ecology and applies it to a set of 9 sleep ethnographies elicited from long-term fieldworkers on societies across a world-wide range of traditional forager, pastoralist, horticulturalist, and agriculturalist communities. The data consistently show that the sleep pattern, architecture, and ontogeny of western postindustrial populations may be grounded in a distinctive sleep ecology, from infancy on, and that comparative, cross-cultural investigation will be required for a more complete understanding of human sleep, its developmental and regulatory neurobiological substrates, and its chronobiological correlates.

Stable isotopic analysis of enamel microsamples: examining childhood dietary change at Kaminaljuyu, Guatemala. L.E. WRIGHT, Department of Anthropology, Texas A&M University, College Station, TX 77843-4352

Previous research at Kaminaljuyu has shown that childhood dietary change can be reconstructed from the stable isotopic composition of permanent

teeth. Using enamel samples that span the full period of crown formation, premolars (P) and third molars (M3) were found to be higher in $\delta^{13}\text{C}$ than first molars (M1), indicating a shift in carbon intake from mothers' milk to solid foods. But, M3 show lower $\delta^{18}\text{O}$ than M1 or P, presumably due to a reduced intake of heavy water from milk after weaning. This suggested an early introduction of solid foods, but continued breastfeeding.

Using an M1 and a P each from 16 Early Classic (AD 400-600) skeletons, I reexamine this pattern at higher resolution using small samples of enamel. Enamel fragments were embedded in epoxy and sectioned longitudinally. Using a slow-speed Brasseler tungsten-carbide dental drill, three 2 mg samples were removed from each section along the DEJ: near the tooth cusp, at mid-crown and at the cervical border. Powdered enamel was reacted with 100% H_3PO_4 at 80°C in a Kiel carbonate device and the evolved CO_2 fed directly to a Finnegan mass spectrometer.

Sequential changes of $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ in enamel microsamples indicate considerable variability in childhood dietary change at Kaminaljuyu. Most skeletons show a rapid rise in $\delta^{13}\text{C}$ only in the cervical P enamel, indicating increased maize consumption near 5 years of age. While $\delta^{13}\text{C}$ of a few skeletons increased earlier, at 2 years of age, others declined in $\delta^{13}\text{C}$ at 2 years. Most skeletons show gradual decline in $\delta^{18}\text{O}$ with age, but several show marked change suggesting abrupt weaning. Social implications of this variability for the Early Classic state are discussed.

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Rethinking the positional repertoire of *Oreopithecus*. R.E. WUNDERLICH. Center for Locomotion Studies, A. WALKER, Anthropology, Penn State University, University Park, PA 16802; W.L. JUNGERS, Anatomical Sciences, SUNY, Stony Brook, NY 11794.

Despite a suite of skeletal features in *Oreopithecus bambolii* that imply a highly suspensory repertoire, Köhler and Moyà-Solà (1997) have suggested that this Miocene ape practiced habitual bipedalism. We examine the evidence for this assertion in light of convergent morphology with living hominoids, sloths and the highly suspensory "sloth lemurs" from Madagascar.

The body proportions and thoracic shape of *Oreopithecus* have been described previously as characteristically hominoid. Many features of the pelvis, femur and foot, posited to be adaptations for bipedality in *Oreopithecus*, are also found in highly suspensory mammals. An ischial spine, for example, is found not only in *Oreopithecus* and *Homo sapiens* but also in sloths, *Palaeopithecus*, *Babakotia*, and weakly in *Pongo*. Its presence in suspensory forms results from a pelvic loading regime in which the presence of a robust sacrospinous ligament resists the tendency of pelvis to twist relative to the sacrum during quadrupedal hanging. The valgus knee of

Oreopithecus is similar in form and degree not only to hominids but also to *Palaeopithecus*. The foot proportions, *contra* Köhler and Moyà-Solà, typify all hominoids, which are characterized by metatarsal proportions (e.g., relative length and robusticity) that emphasize the medial side of the foot. This arrangement is associated with use of the medial forefoot at the end of stance phase on arboreal supports in nonhuman hominoids. Habitual bipedality in humans is characterized instead by robust fifth and proximal fourth metatarsals. *Oreopithecus*, however, is estimated to be similar to *Pongo* in the gracility of the lateral metatarsals.

Our conclusions do not support the suggestion that features of the pelvis, femur and foot presented by Köhler and Moyà-Solà necessarily imply habitual bipedalism in *Oreopithecus*. The morphology discussed here, along with previous evidence, support the notion of an arboreal, and likely highly suspensory, lifestyle for *Oreopithecus*.

Effect of maternal infant-handling behaviors on neuromuscular development in rural Papua New Guinea. S.L. WYCKOFF¹, M.G. WIMMER¹ AND D.P. TRACER². ¹Dept. of Anthropology, University of Washington, Seattle, WA 98195. ²Health and Behavioral Sciences Program, University of Colorado, Denver, CO 80204.

While a plethora of studies have measured normal somatic growth in a wide range of non-western populations, to date, few have characterized patterns of neuromuscular development outside of a western context. Despite this lack of data, however, it is widely assumed that the western sequence and timing of neuromuscular development is normative and ubiquitous throughout the human species. Moreover, deviations from the western pattern are widely seen as indicative of developmental delay or pathology. In order to address these assumptions, we present data on the course of neuromuscular development from a pilot study conducted among the Au forager-horticulturalists of Papua New Guinea.

Motor assessments were carried out on 20 Au infants ages 3-30 months using the Bayley Motor Scales of Infant Development-II. The Scales consist of a roster of age-specific tasks that measure gross and fine muscle control as well as movements associated with early locomotion. Six hour focal follows on infants and their mothers were also performed in order to characterize prevalent types of maternal infant-handling behaviors.

While Au infants routinely fail tasks conducted in the horizontal plane such as rolling from side to back and elevating themselves by the arms, they nevertheless pass those tasks conducted in a vertical plane such as holding the head erect and sitting unassisted. Au infants also do not exhibit a "crawling" phase, widely regarded in the western literature as a necessary prerequisite to walking, but instead, pass through a "scoot" phase, propelling themselves asymmetrically by the arms and legs in an upright sitting posture. We tentatively attribute the particular course of neuromuscular development seen among the Au to maternal infant-handling behaviors including near-continuous carrying of infants in a sling with infants' hips hyper-flexed. This study is among the first to demonstrate the culturally-contingent nature of normal neuromuscular development.

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DNA diagnosis of thalassemia from ancient Italian skeletons. D.Y. YANG^{1,3}, L. BONDIOLI², R. MACCHIARELLI², B. ENG³, J.S. WAYE³, S.R. SAUNDERS¹. Department of Anthropology¹, Department of Pathology and Molecular Medicine², McMaster University, Hamilton, Ontario L8S 4L9, Canada, L. Pigorini National Museum of Prehistory and Ethnography³, Rome, Italy

We report our attempt to extract DNA from the skeletal remains of five young children who died approximately 1,900 years ago and who were recovered from an Italian archaeological site, Isola Sacra. These skeletons have been tentatively diagnosed as thalassemics based on morphological observations, but alternative diagnoses are also possible. DNA diagnosis was used to attempt to identify thalassemia mutations from the human globin genes extracted from these skeletons.

Ancient DNA was successfully extracted from some skeletons using the silica-based spin column method. PCR amplification was achieved by a semi-nested PCR protocol. DNA fragments were then confirmed by the Dot Blot test and direct DNA-sequencing analysis.

The results suggest that ancient human β -globin genes were extracted from three of the five individuals from Isola Sacra. DNA diagnosis for two of the most common Italian thalassemia mutations, IVS1-110 and codon 39 (more than 50% of current Italian thalassemia mutations), revealed that these three individuals did not have these two mutations. However, the present results cannot totally exclude the possibility of thalassemia from these specimens since five other untested mutations might occur in these specimens.

Precautions were taken to minimize the risk of contamination. Contamination was also monitored by mtDNA analysis of each individual. No systemic contamination took place in this study but a sporadic contamination was identified with one specimen.

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Variation in Neandertal internal nasal morphology: evidence from Krapina and Vindija. T. R. YOKLEY, Department of Anthropology, Northern Illinois University, DeKalb, IL 60115.

In a recent study, Schwartz and Tattersall (1996) outlined a series of proposed autapomorphic features for the internal nasal region of Neandertals. These features include the presence of an internal nasal margin with a medial projection, the medial expansion of the nasal cavity wall into the posterior portion of the nasal cavity, and an exposed lacrimal groove. Their study noted the presence of these features in a small sample of Neandertals from Western Europe. Excluded from their study, perhaps because of their fragmentary nature, were Neandertal specimens from the Croatian sites of Krapina and Vindija.

The present study analyzes maxillary fragments from these two collections that preserve portions of the

nasal aperture and the nasal cavity. Where applicable, presence or absence of the proposed autapomorphic features was determined. Patterns of cresting in the lower part of the nasal aperture were also observed for both samples. The internal nasal morphology of an extensive modern sample from the skeletal collections at the Field Museum in Chicago and the Croatian Natural History Museum was also documented and compared to the morphology of the Krapina and Vindija Neandertal samples.

Results of this study indicate a pattern not entirely consistent with the Schwartz and Tattersall study. One specimen from Krapina is lacking a medial projection, and one specimen from Vindija does not have medial expansion of the lateral nasal cavity wall. Thus, by increasing sample size with specimens from Krapina and Vindija, use of two of these traits as autapomorphic Neandertal features becomes questionable. The nasal cresting patterns of Krapina and Vindija differ from specimens analyzed in the Schwartz and Tattersall study as well as from each other. The nasal crests of the Vindija specimens demonstrate a reduction in both size and proximity to other crests relative to the Krapina specimens. This analysis is consistent with the overall pattern of reduction that has been documented for other aspects of cranio-facial morphology of the Vindija Neandertals.

Age Changes in the Auricular Surface of the Sacroiliac Joint in *Macaca mulatta*. H.P. YORK, C.O. LOVEJOY and R.S. MEINDL. Department of Biomedical Sciences, Kent State University, Kent, OH 44242

The appearance and texture of the auricular surface of the normal human sacroiliac joint changes progressively with extreme age (Meindl & Lovejoy, 1989, In M.Y. Iscan, ed. *Age Markers in the Human Skeleton*. pp. 137-168). This has implications for both comparative primate anatomy and paleodemography.

Lovejoy *et al.* (1997, In R.R. Paine, ed. *Integrating Archaeological Demography*. pp. 43-63) tested auricular surface age progression in gorillas and chimpanzees by comparing it to dental wear. They found that this method was as useful for predicting the ages of these hominoids (especially for the greatest ages) as it is for humans, and more informative than any other indicator, save perhaps dental eruption and wear. Thus, despite the locomotor and parturitional differences between ape and human pelvises, a basic pattern of auricular surface change is shared by hominoids.

Comparisons between hominoid and cercopithecoid pubic symphyseal changes have shown that the two taxa do not share the same relative timing or mode of fusion at this joint (Tague, 1990, *Am. J. Phys. Anthropol.* 82:517-525). However, no such comparisons have yet been made between hominoid and cercopithecoid sacroiliac joint changes.

We tested the effectiveness of using the auricular method for predicting age in 57 adult male and female macaques. Relationships between auricular surface age estimates and recorded ages of the cercopithecoid sample are comparable to those found by Lovejoy *et al.* (1997) for humans.

Implications of the comparable progression of sacroiliac maturation and senescent degeneration in primates are discussed.

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Estimated body weight and degree of sexual dimorphism for *Victoriapithecus macinnesi*, a Miocene cercopithecoid. S.N. ZAMBON, M.L. McCROSSIN, and B.R. BENEFIT, Department of Anthropology, Southern Illinois University, Carbondale, IL 62901.

Body weight estimates for fossil taxa have important implications for evaluating their dietary and locomotor adaptations, relative brain size, and reconstructing the communities in which they lived. Based on postcranial material collected at Maboko Island, Kenya prior to 1987, Harrison (1989) estimated the body weight of *V. macinnesi* as falling between 3.5 and 4.0 kg. New postcranial material collected at Maboko since then is used here to provide further information about the body weight of *V. macinnesi*, and to estimate levels of sexual dimorphism which may have characterized the Miocene monkey.

In this study, eleven postcranial measurements from the humerus, ulna, radius, ischium, femur, tibia and astragalus were taken from the new fossils as well as from Harrison (1989). In order to perform a regression analysis for each of these measurements against body weight, the same suite of measurements was taken from a population of wild-shot vervet monkeys (*C. aethiops*) of known body weight from Kibwezi, Kenya. Regression equations were generated for the Kibwezi vervets using Statgraphics, and used to estimate the body weights of *V. macinnesi*.

The new average body weight estimate for *V. macinnesi* is 3.1 kg, with a range of 2.4-4.1 kg. This range is larger, and the mean lower, than that obtained by Harrison (1989). It is also considerably lower than body weight estimates based on dental dimensions (Gingerich et al. 1982, Conroy 1987). It has previously been established that *V. macinnesi* was sexually dimorphic (Benefit 1993), and new postcranial measurements support this idea. Given that most body weight estimates for *Victoriapithecus* fall into two size clusters, it is likely that body weight estimates of 2.4-3.1 kg represent females, and those of 3.3-4.1 kg represent males. This degree of sexual dimorphism is shared with an eclectic group of living cercopithecoids, including *Pygathrix nemaeus*, *Macaca nemestrina*, and *Colobus angolensis*, and may represent the ancestral cercopithecoid condition.

Mitochondrial DNA Variation in China. C. Zhang and D. A. Merriwether, Departments of Anthropology and Biology, University of Michigan, Ann Arbor, MI 48109-1382

The first hypervariable region of the mitochondrial DNA control region (nts 16024-00031 of the Anderson et al.,

1981 reference sequence) was sequenced for 112 unrelated individuals randomly sampled from all over China. An additional 72 samples were sequenced for 16024-16398. Samples were provided by the central government forensic laboratory in Beijing. Analysis of the mitochondrial genetic variation in these samples showed that despite the very wide geographic range in origins for the samples within China, the variation was tightly clustered around a number of common patterns. Considerable genetic similarity was noted between these Chinese samples and other published East Asian mitochondrial DNAs. We detected 152 different haplotypes in 184 sequences. Gene flow estimates were calculated between the Chinese population and Korea, Japan, Mongolia, and a number of Melanesian and Polynesian populations, as well as with the New World. Mismatch distributions were used to estimate expansion times for the Chinese population, and for the major clusters of Chinese sequences.

Extraction of DNA and PCR analysis of DNA from free-ranging howling monkey (*Alouatta palliata*) feces. X. ZHANG, L. WINKLER and R. FERRELL, School of Public Health, University of Pittsburgh, Pittsburgh, PA 15261.

The analysis of DNA from fecal specimens offers a noninvasive and easily accessible means of analyzing the genetic diversity and paternal relationships within wild monkey groups. However, there have been a number of problems in extracting DNA from feces, including the limited amount of DNA in the samples, difficulty in degradation, and the presence of secondary compounds which function as inhibitors during the process of amplifying DNA via PCR techniques. The latter problem may be further complicated in howling monkeys by their dietary specializations which include substantial quantities of leaves and associated secondary compounds (Glander, 1978). The present paper describes a method of successful DNA isolation and amplification from feces of free-ranging mantled howling monkeys (*Alouatta palliata*).

Fresh fecal samples were collected and stored in ethanol by one of us at La Suerte Biological Research Station, Costa Rica and Ometepe Biological Research Station, Nicaragua in July and December of 1997. DNA was extracted from 12 samples by a protocol modified from Deuter et al. (1995) which uses a stool lysis buffer and potato flour as an absorption matrix for inhibiting compounds during the initial isolation of DNA from the stool specimen. After 12 hours of digestion with proteinase K (2.5mg/ml), DNA was purified using Qiagen kits (Qiagen, Hilden, Germany) as described by the manufacturer. Initially DNA was amplified via PCR using 5 human microsatellite loci identified for various Platyrrhine species (Ellsworth and Hoelzer, 1997). DNA was successfully amplified in 50% of the fecal samples for 4 of these loci. We processed DNA from all 12 samples a second time using PCR technique for five additional loci identified for the mantled howling monkey (Ellsworth and Hoelzer, 1997) and modified the procedure to include double amplification during the PCR process. This second PCR amplification yielded DNA for 83% (10/12) of the samples for one of these five markers but none for the remainder. DNA from humans and captive howling monkeys were used as a control in all procedures.

Analysis of DNA from feces offer great potential for genetic analysis of wild monkey populations. However, although we successfully isolated DNA, we were unable to amplify it for all known markers. Our best results were obtained with loci which had the shortest PCR fragment length (154, Ellsworth and Hoelzer, 1997). The small amount of DNA present in fecal material, the difficulty in preventing degradation, and the presence of inhibitors continue to be a problem. Because of DNA degradation, successful genotyping of howling monkeys from fecal samples may require that amplification primers be designed to amplify sites of interest in fragments of 150bp or less. We acknowledge La Suerte and Ometepe Biological Research Stations. This project was supported by research funds from the University of Pittsburgh.

Should muscle have most favored tissue status?
A.L. ZIHLMAN, University of California, Santa Cruz 95064 and R.K. McFARLAND Cabrillo College, Aptos, CA 95003.

The complete, tissue-by-tissue dissection of 15 adult African apes (5 *Gorilla*, *P. paniscus*, *P. troglodytes*) provides a unique data set for documenting variation of major tissues (bone, muscle, fat, skin) and for interpreting the significance of body weight. Differences in the components correlate with locomotor adaptation, others with individual life history: age, sex, reproductive state. Three tissues (bone, muscle, skin) constitute 45 to 85% in our sample. Bone varies the least (from 10 to 15%), muscle and fat the most. Muscle is 16% of total body mass in an elderly female gorilla, but over 50% TBM in a healthy male pygmy chimpanzee. Adipose stores range from 2-3% in three pygmy chimpanzees to more than 40% in the elderly female gorilla.

Such data on inter- and intraspecific variation add an important dimension to discussions of human evolution and serve as a counterpoint to "the expensive tissue hypothesis." The hypothesis relies upon human data: the brain, although 2% of total body mass, accounts for 15% of total basal metabolic rate, the guts at 6.8% TBM accounts for 60% BMR, but muscle tissue at 40% TBM accounts for 15% of BMR. The argument is that as brain tissue increased from 1 to 2% during hominid evolution, the GI tract somehow declined in proportion in order to account for the increased metabolic load. The hypothesis fails to consider all the major tissues of the body (e.g. skin, bone, fat) or the variable tissues associated with locomotion, especially muscle and therefore ignores the energetic costs associated with physical activity. A realistic starting point must deal with the distribution and redistribution of muscle mass in human evolution, its relationship to locomotor adaptation, and the consequent shift in metabolic demand.

Form differences in the fetal craniofacial complex: A three dimensional (3D), morphological comparison between fetal pigtailed macaques (*Macaca nemestrina*) and humans (*Homo sapiens*). M. P. ZUMPARO, The Johns Hopkins School of Medicine, Department of Functional Anatomy and Evolution, Baltimore, MD 21205

While the form of the fetal craniofacial complex has been well documented in humans and in pigtailed macaques in two dimensions, there are no investigations that directly compare the fetal craniofacial morphology of these two primates. The purpose of this research is to provide the first three dimensional comparison of fetal craniofacial morphology between *M. nemestrina* and *H. sapiens*. Euclidean Distance Matrix Analysis (EDMA) is used to test the null hypothesis that the macaque and human fetal craniofacial complex have similar forms.

The populations consist of 18 pigtailed macaques fetuses (9 male and 9 females; mean age of 21 weeks) and 15 human fetuses (8 males and 7 females; mean age of 29 weeks). Birth for the pigtailed macaque is estimated at 24.3 gestational weeks, while 40 gestational weeks is the estimated gestation time for humans. Chronologically, the macaque population has completed 86% of their gestation, while the human population has completed 72% of their gestation.

Three dimensional (3D) coordinates of 14 landmarks on the face and inferior neurocranium were collected from 3D-CT reconstructed images and 2D axial slices. For the human specimens, 3D coordinates were digitized using REMEDI, while landmarks for the macaque specimens were digitized using VoxBlast. EDMA was used to test each population for the presence of sexual dimorphism. No sexual dimorphism was present, thus males and females were combined in each population.

Results from EDMA failed to support the null hypothesis. There were significant differences in the overall form of the fetal craniofacial complex. The inferior neurocranium and upper face is wider along mediolateral axes in the macaque skull, relative to the human skull. The macaque middle cranial fossa is shorter along anteroposterior axes, and the midface is more prognathic in the macaque. Finally, the entire cranial base in the macaque is shorter, relative to the human.

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